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# Analysis of Pyrolysis Products of Sewage Sludge: Investigation of a Range Fire at Aberdeen Proving Ground (APG)

by Rose Pesce-Rodriguez

ARL-MR-332

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Rose Pesce-Rodriguez  
Weapons and Materials Research Directorate, ARL

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## Abstract

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Soil, sludge, and ash samples taken from Range-16 (R-16) on Spesutie Island, Aberdeen Proving Ground (APG), were analyzed by pyrolysis-GC-FTIR-MS. The objective of the investigation was to identify toxic combustion/pyrolysis products that may have been responsible for physical discomfort and muscle spasms experienced by range personnel who attempted to extinguish a fire, which occurred on the range on 16 March 1995. It was found that the sludge samples generate small quantities of many cyclic and noncyclic hydrocarbons, including benzene, toluene, phenol, and acetaldehyde. The most interesting and potentially important finding of this investigation was that sludge samples from both R-16 and Phillips Air Field (PAF) contain the dodecyl ester of acrylic acid [ $\text{CH}_2\text{CHCOO}(\text{CH}_2)_{11}\text{CH}_3$ ]. Toxicity data for a related ester suggests that the material is moderately toxic, a fire hazard, and emits acrid smoke when heated to decomposition. Based on a limited survey of the literature, it does not appear that esters of acrylic acid should be present in sludge.

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## 1. BACKGROUND

In March 1995, a fire occurred on the grounds of a U.S. Army Research Laboratory (ARL) firing range at Aberdeen Proving Ground (APG). The fire differed from other fires that occasionally break out among dry vegetation surrounding the range in that it was reportedly very difficult to extinguish and appeared to repeatedly reignite over a several-day period subsequent to the initial fire. It also differed from previous fires in that the area surrounding the range contained not only the "usual" vegetation but also dried sewage sludge that had been applied to the grounds. Range personnel involved in extinguishing the fire reported physical discomfort, including muscle spasms and skin irritation. The Risk Management office of ARL arranged for chemical analysis of the soil and sludge to be performed by an outside laboratory, but also wanted to have analysis of the pyrolysis/combustion products of sludge and soil samples performed in-house (by the Chemical Characterization Team of the Ignition and Combustion Branch [CCT/ICB]). It was agreed that this analysis would be performed by means of pyrolysis/combustion-GC-MS-FTIR (gas chromatography-mass spectrometry-Fourier transform infrared [IR]) spectroscopy.

The CCT was provided no information regarding the content of the sludge that was delivered for analysis, other than the description written on the label for each sample (see Table 1), and being told that the sewage had been treated prior to having been applied to the ground surrounding Range-16 (R-16).

Table 1. Samples Provided for Analysis

Designation	Sample	Description
1	Soil	R-16, unburned, no sludge
2	Soil	R-16, unburned, with sludge
3	Soil	R-16, burned, no sludge
4	Soil	R-16, burned, with sludge
5	Sludge	R-16, unburned
6	Sludge	R-16, fringe of burned/unburned region
7	Sludge	R-16, ash, from burned region
8	Sludge	R-16, North No. 1 <sup>a</sup>
9	Sludge	R-16, North No. 2 <sup>a</sup>
10	Sludge	Phillips Air Field <sup>a</sup>

<sup>a</sup> Delivered to CCT/ICB on 28 April 1995.

## 2. EXPERIMENTAL

2.1 Sample Preparation. Samples were analyzed in two forms: 1) as received, and 2) after acetone extraction (extracts were also analyzed). Extractions were performed by placing approximately 20 mg of sewage sample in approximately 2-mL acetone. After mixing the sample for approximately 2 min, the solution was filtered through a 2- $\mu$ m polytetrafluoroethylene (PTFE) filter and collected for further analysis. After complete evaporation of the acetone from the extracted solution, a yellowish, waxy solid material was obtained. (The extract was allowed to dry under atmospheric conditions.) After having analyzed the extracts of the R-16 and Phillips Air Field (PAF) samples, and having obtained unexpected results, a second set of samples was extracted and filtered as described previously. After 1 day, the samples were observed to be viscous fluids. Analysis indicated that no residual acetone was present in the samples.

2.2 Instrumentation. With Pyrolysis-Gas Chromatography-Fourier Transform Infrared (Spectroscopy)-Mass Spectroscopy (P-GC-FTIR-MS), the pyrolysis products of a sample are rapidly generated and passed through a GC column, where they are then separated based on their affinity for the column's stationary phase. After passing through infrared and mass spectrometric detectors, identification of the analyte may be obtained. A schematic representation of the apparatus is given in Figure 1. In all but one case, the mass spectrometer was the detector of choice because of its greater sensitivity.

Pyrolysis was achieved by means of a CDS Model 122 Pyroprobe (coil-type probe). Approximately 2 mg of each sample were placed in quartz tubes that fit within the coils of the pyroprobe. A plug of glass wool at one end held the sample in place. The pyroprobe was connected via a heated interface chamber to the splitless injector of a Hewlett Packard (HP) 5980 GC. The GC column was, in turn, connected in parallel to the light pipe of a HP 5965 IRD dedicated infrared detector (with a narrow band mercury-cadmium-telluride [MCT] detector) and a HP 5970 MSD dedicated mass spectrometric detector.

The GC column used was a Quadrex capillary column (0.32 mm  $\times$  25 m) with a stationary phase composed of a 3- $\mu$ m OV-17 film. The temperature program used was as follows: 50° C for 3 min, and then 50–250° C at 20°/min. The GC injector and pyroprobe interface chamber were held at 200° C and 150° C, respectively. The temperature of transfer lines to the infrared detector (IRD) and mass spectroscopy detector (MSD) were held at 200° C, as was the IRD light pipe. The flow rate of the carrier gas (ultrahigh purity [UHP] helium) was 40 mL/min. Although carrier gas was continuously swept

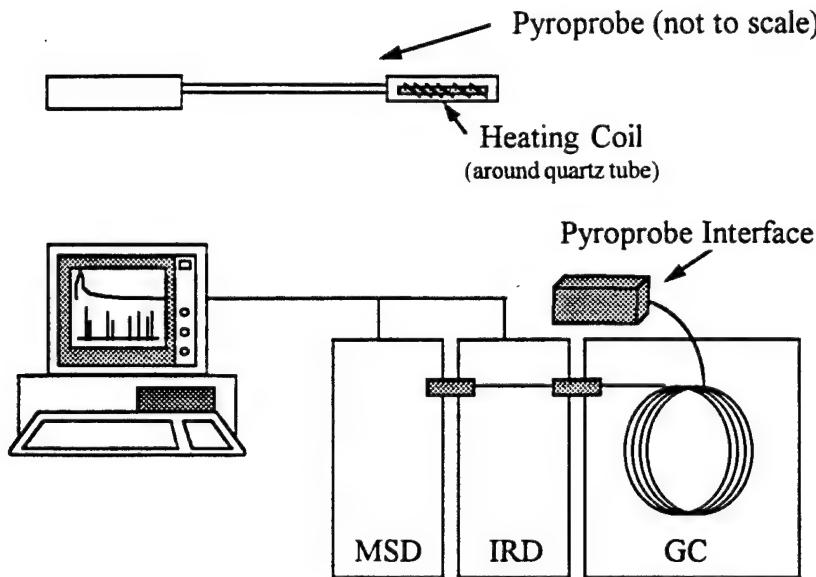


Figure 1. Experimental apparatus.

through the pyroprobe interface, a small amount of air was present during the pyrolysis, due to air trapped in the porous sample and to air entering the system when the pyroprobe is introduced into the interface chamber.

**2.3 IRD Conditions.** Three interferograms per second were continuously collected at  $8 \text{ cm}^{-1}$  resolution during the chromatographic run. Real-time chromatograms (IR response vs. time) were recorded via application of the Gram-Schmidt algorithm (Griffiths and de Haseth 1986).

All functions were controlled by means of HP software running on a HP 486 Vectra PC. Manipulation of FTIR data was performed using Grams386 software.

Online searches of IR spectra were performed using the Sadtler software/database, which contains in excess of 85,000 IR spectra. Searches of mass spectra were performed using HP software and the National Bureau of Standards (NBS) database, which contains in excess of 75,000 spectra.

**NOTE:** Although it was initially agreed that both combustion and pyrolysis experiments would be performed on the sludge samples, it was determined that the sludge samples did not ignite when in contact

with the hot wire ignitor used in the CCT/ICB combustion chamber. For this reason, only pyrolysis experiments were performed.

### 3. RESULTS

Although CCT/ICB was provided with 10 samples for analysis, emphasis was quickly shifted away from the samples of soil and burned sludge and towards the unburned sludge samples from R-16 and PAF, also located at APG. This shift in emphasis resulted primarily from the observation (based on chemical analysis) that neither the soil samples nor the burned sludge samples contained materials of interest. Organic matter in the soil sample was composed primarily of cellulose-based material. The burned sludge samples were sufficiently decomposed to yield little organic matter. The PAF sample was analyzed to provide material for comparison with the unburned R-16 samples.

For documentation purposes, the gas chromatogram of the pyrolysis products of the unburned soil sample is given in Figure 2. The large peak near the 1-min mark is assigned to water. The much smaller peaks between the 5- and 10-min marks are due to acetic acid and furan carboxaldehyde (suspected to be products of cellulose pyrolysis). Since the analysis of the sludge ash sample showed no observable peaks, its chromatogram is not shown here.

Results from the pyrolysis of the unburned R-16 sludge sample at 500° C are shown in Figure 3. The observed peaks may be broken down into two groups (i.e., those eluting between 0 and 2 min, and those eluting between 8 and 16 min). The four peaks in the first group are assigned to air trapped while introducing the pyroprobe into the interface chamber, air trapped in the porous sludge sample, water, and what appears to be acetaldehyde, respectively. Acetaldehyde is a flammable liquid having a boiling point of 21° C, and therefore not expected to have been present in the sample prior to pyrolysis (since it would have vaporized and escaped from the sample prior to analysis). The second group of peaks in Figure 3 has mass spectra that are typical of cyclic and polycyclic hydrocarbons, and noncyclic hydrocarbons of moderate chain length (i.e., less than C<sub>20</sub>). A list of some of the pyrolysis products observed when a sludge sample is given a 500° C pulse is given in Table 2. A list of products observed when the same sample is given a subsequent 1,000° C pulse is also given.

Analysis of the PAF sludge sample gives results (Figure 4) that are strikingly similar to those of the R-16 sludge sample. This suggests that it is unlikely that the R-16 sludge was contaminated unless the PAF sample was *also* contaminated in the same fashion.

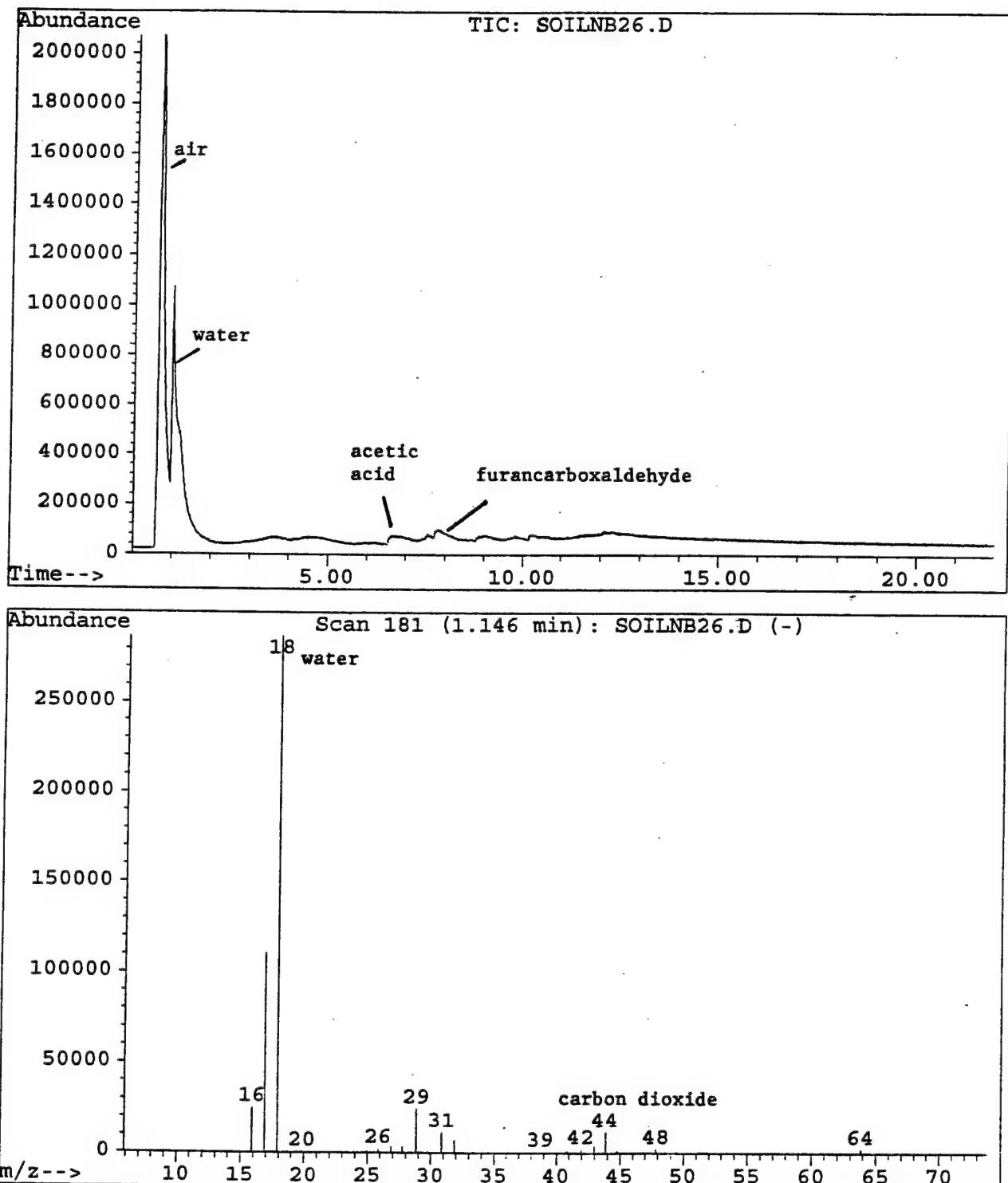


Figure 2. Pyrolysis-GC-MS results for R-16 soil sample containing no sludge (600° C pulse).

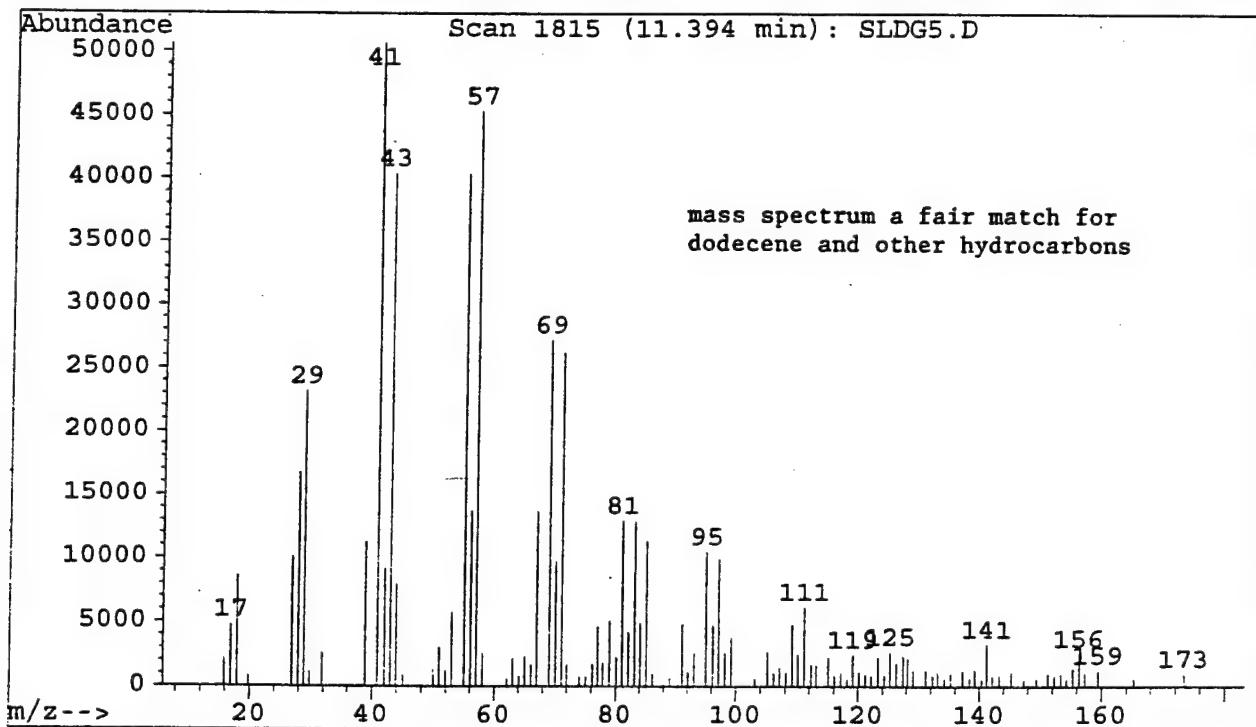
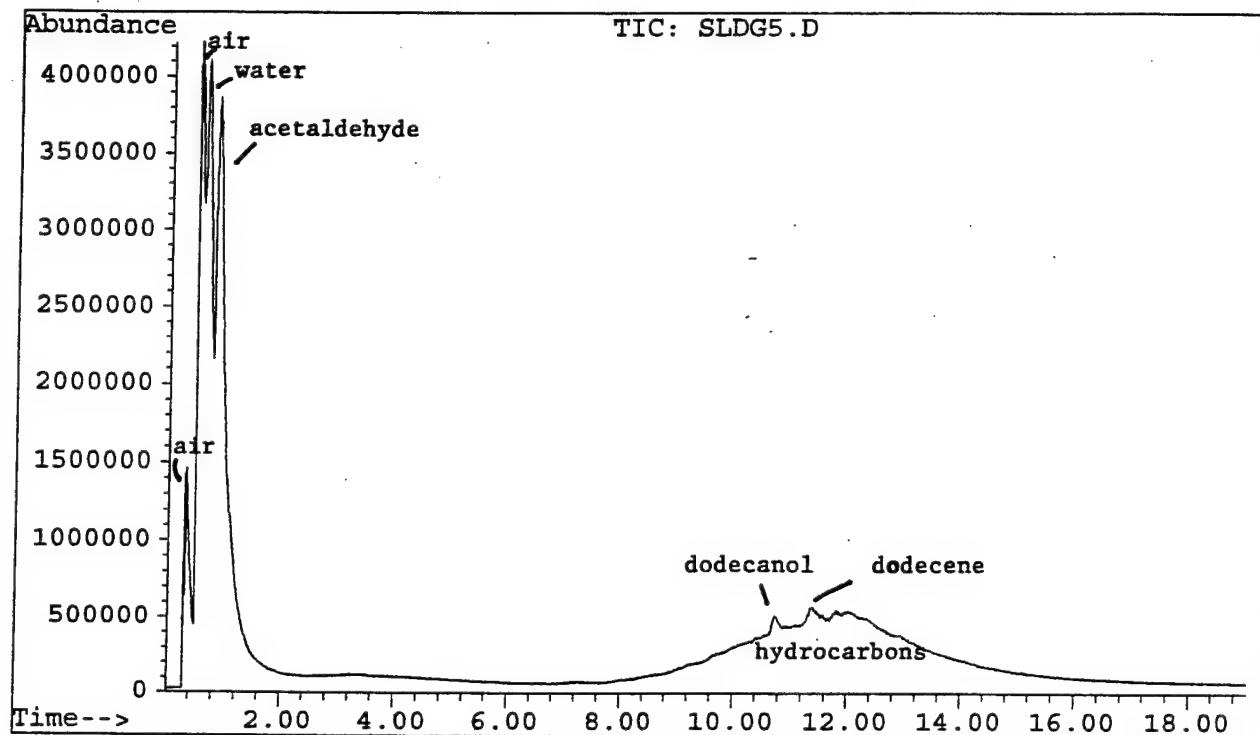


Figure 3. Pyrolysis-GC-MS results for R-16 sludge sample (500° C pulse).

Table 2. Products From Pyrolysis of R-16 Sludge Samples

Pyrolysis Products (500° C Pulse)	Pyrolysis Products (1,000° C Pulse)
Acetaldehyde	Acetaldehyde
3-Methyl-nonane	Toluene
Dodecanol	Benzene
Dodecene <sup>a</sup>	Styrene
2,6,11-Trimethyldodecane <sup>a</sup>	Ethylbenzene
2-Hexyl-1-decanol <sup>a</sup>	Pyrrole
Hydrocarbon <sup>b</sup>	Phenol
Hydrocarbon <sup>b</sup>	2-Methyl Phenol
Hydrocarbon <sup>b</sup>	1,3,5,7-Cyclooctatetraene <sup>a</sup>
Hydrocarbon <sup>b</sup>	5-Methyl-2-furan carboxaldehyde
Hydrocarbon <sup>b</sup>	Naphthalene
Hydrocarbon <sup>b</sup>	1,7-Octadiyne <sup>a</sup>

<sup>a</sup> Fair agreement with library search results.

<sup>b</sup> Poor agreement with specific library search results, but pattern is consistent with a hydrocarbon chain of moderate length.

Pyrolysis of both the R-16 and PAF samples in air (at 500° C, in a quartz tube) resulted first in the generation of moisture, and then a white smoke. Deposits of a waxy material on the ends of the quartz tube were observed when the tube cooled. The odor of the pyrolysis products was sickening to the stomach.

Acetone extracts of the R-16 and PAF samples were obtained, dried under atmospheric conditions, and then analyzed by Desorption-GC-FTIR-MS. Since samples were pulsed at only 250° C, the process is designated as "desorption" rather than "pyrolysis." The intention of these experiments was to determine the identity of the extracted material, rather than of the pyrolysis products of the extracted material. The results obtained from the extracts of the R-16 and PAF samples indicate that they are essentially identical (see Figures 5 and 6). An online search of the FTIR spectrum of the extract indicates with fairly high certainty (match quality = 963/1,000) that the extract is the dodecyl ester of acrylic acid (DEAA) (compare

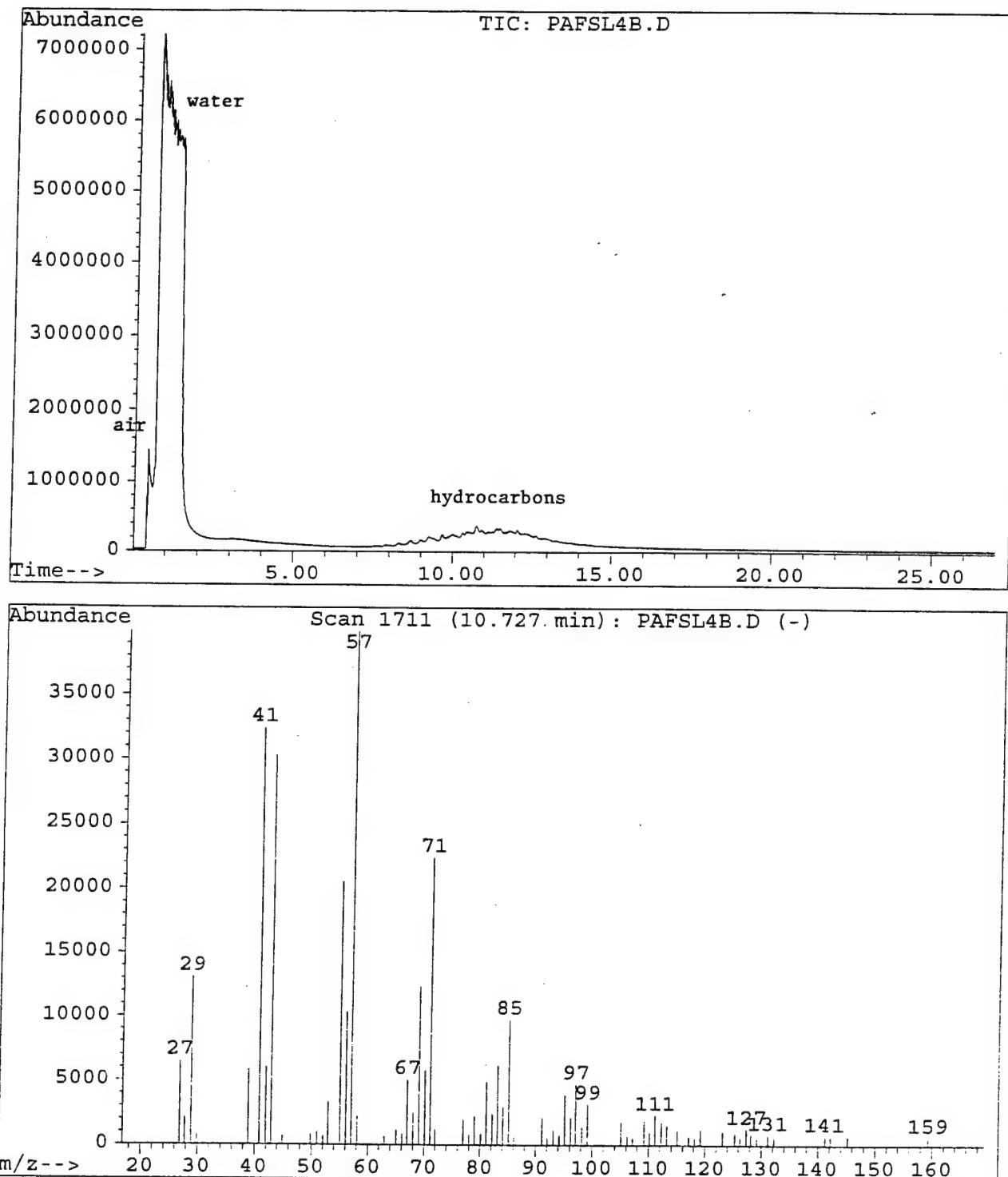


Figure 4. Pyrolysis-GC-MS results for PAF sludge sample (400° C pulse).

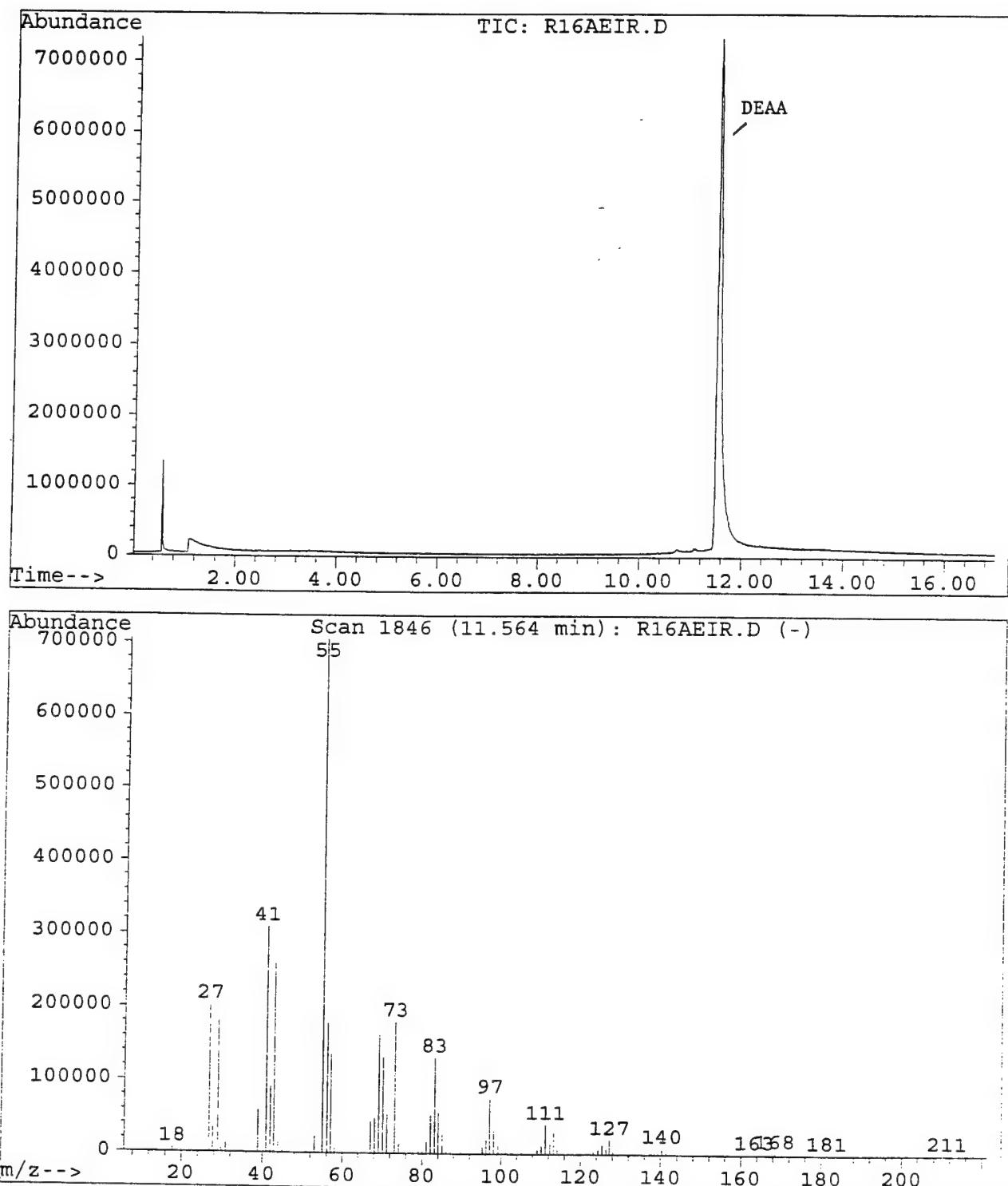
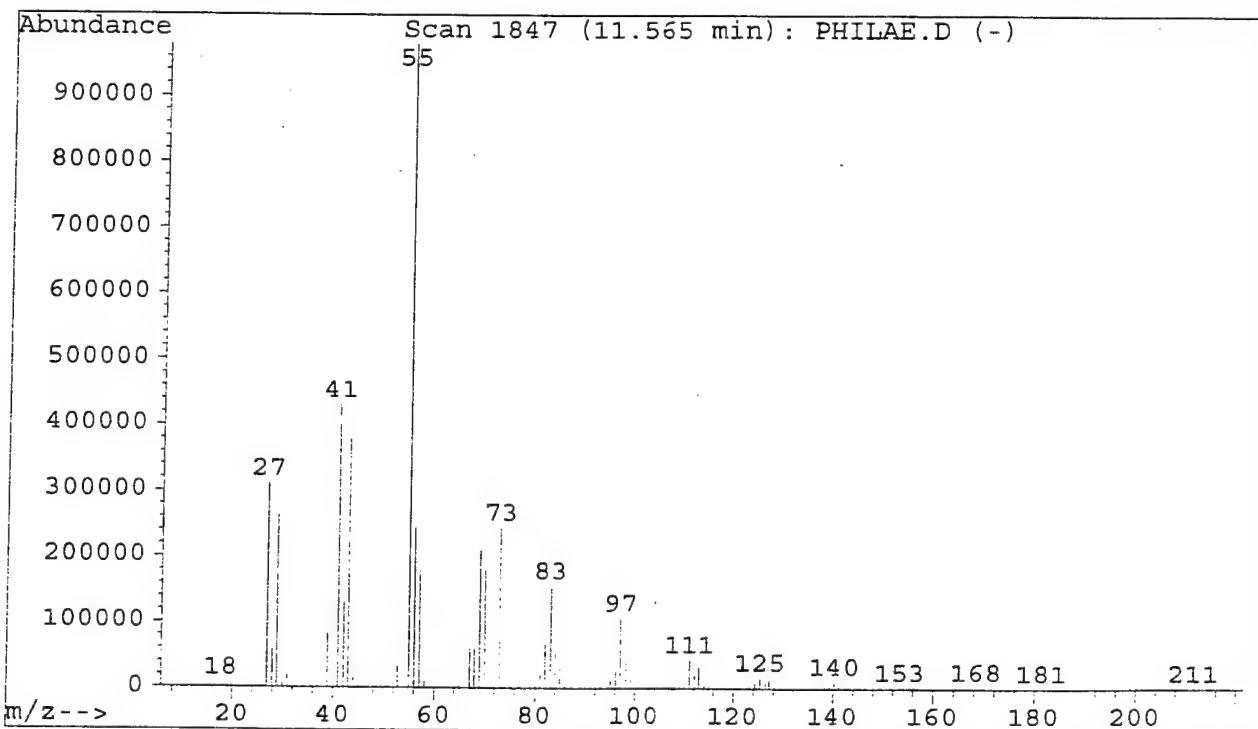
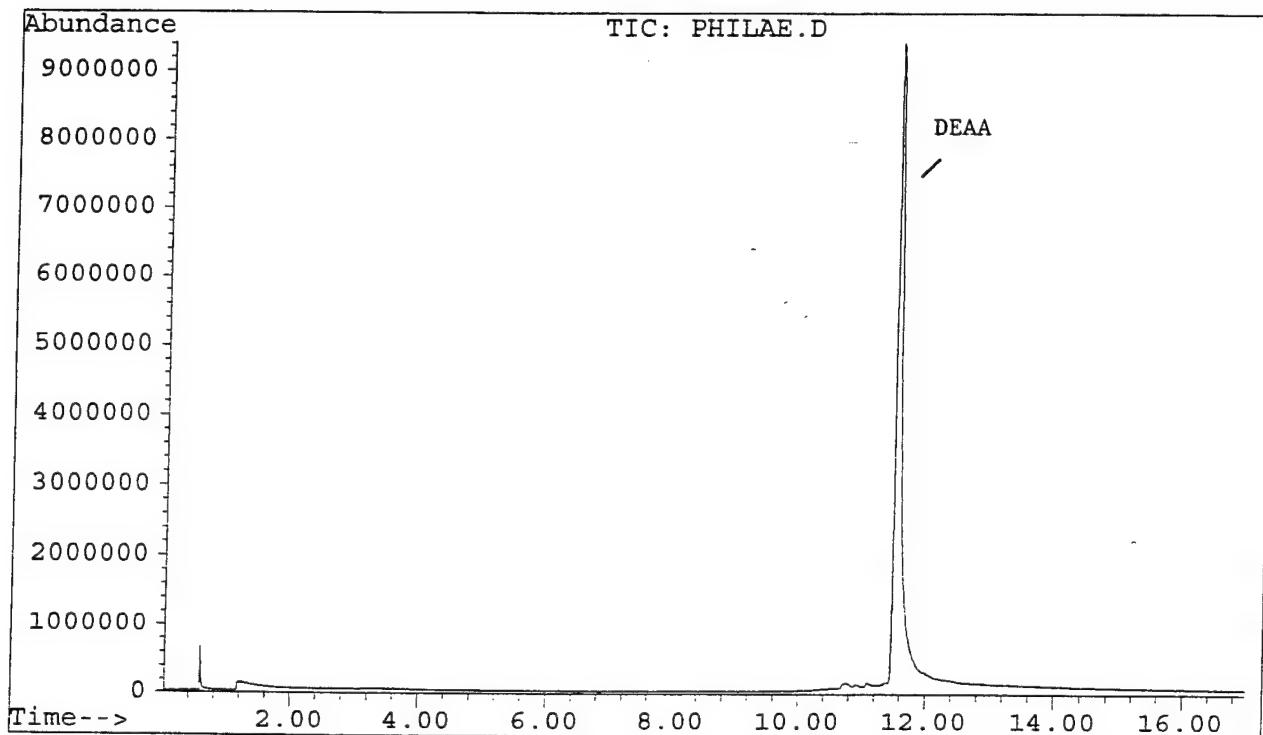


Figure 5. GC-MS results for acetone extract of R-16 sludge sample (250° C pulse). Sample allowed to dry under atmospheric conditions.



**Figure 6. GC-MS results for acetone extract of PAF sludge sample (250° C pulse). Sample allowed to dry under atmospheric conditions.**

Figures 7b and 7c). (Note that the IR spectrum for a specific compound is unique to that compound, i.e., it is highly unlikely that any two organic compounds possess IR spectra identical in both the position and intensity of the peaks.) An online search of the mass spectrum of the material indicates with much lower certainty (match quality = 510/1,000) that the material is dodecene (see Figure 8). Although these results appear to be contradictory, they are not. A name search of the MS database failed to retrieve DEAA, meaning that it would be impossible for DEAA to be identified in a spectral search. The fact that the search retrieved dodecene, which is structurally similar to DEAA, is consistent with the IR results.

A second set of acetone extracts was obtained from both the R-16 and PAF samples. These extracts were allowed to dry for only 1 day before being analyzed by GC-FTIR-MS. Results of these analyses are shown in Figure 9. The mass spectra indicate that, although the samples still appeared to be wet, there was no acetone in the sample; the amount of water in the sample was not significantly greater than in any nonextracted samples. This observation suggests that the sample was "wet" because it contained components other than water or acetone, which are liquids at room temperature. The melting point of DEAA could not be located in the literature, but based on observations of the state of the DEAA extracted from the sludge samples (i.e., a waxy solid, as discussed previously), it is safe to say that DEAA is a solid at room temperature. Considering that the extracts are "wet" after being allowed to dry for just 1 day (and are known NOT to contain residual acetone or water), but "dry" after being allowed to dry for 2 weeks, there are several possible scenarios:

- (1) DEAA is a product of a reaction between extracted materials, and over a 2-week period is the only detectable compound left after consumption of all reagents. (Based on a following discussion under section 4.1 and Figure 11, this is not likely to have occurred.)
- (2) Materials other than DEAA are extracted from the sludge and give rise to the broad peak between 8–16 min, but eventually evaporate from the sample. (This is possible, but difficult to confirm with limited data.)
- (3) Although extraction and filtering conditions were approximately identical for both the dry samples and the samples which had been dried for only one day, there was some difference that favored extraction of the liquid components. (This is also possible but difficult to confirm with limited data. NOTE: for the second set of extractions, the amount of dry sample used was two to three times larger than in the first set of extractions.)

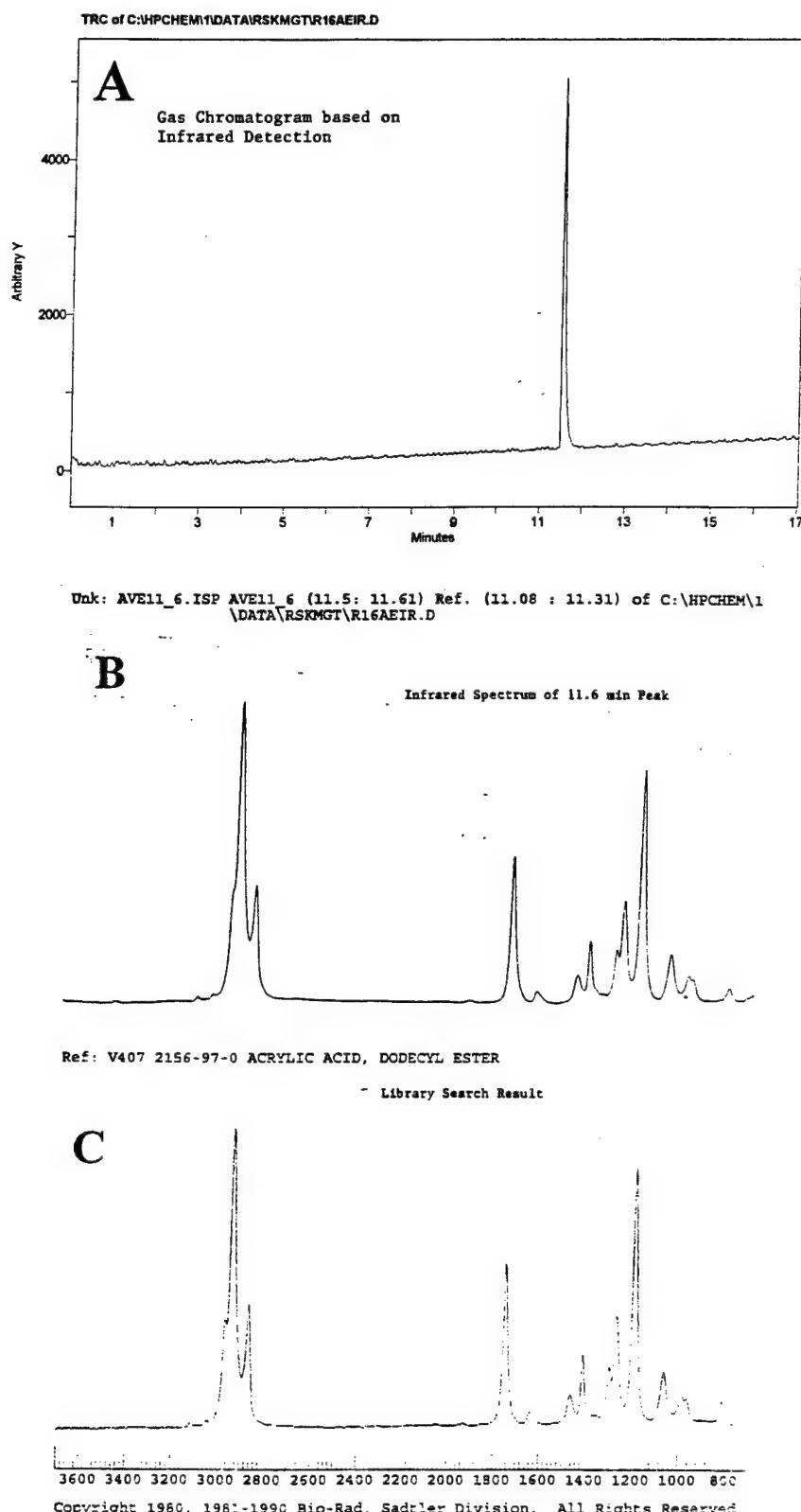


Figure 7. GC-FTIR results for acetone extract of R-16 sludge sample (250° C pulse). Library match obtained using Sadler IR database.

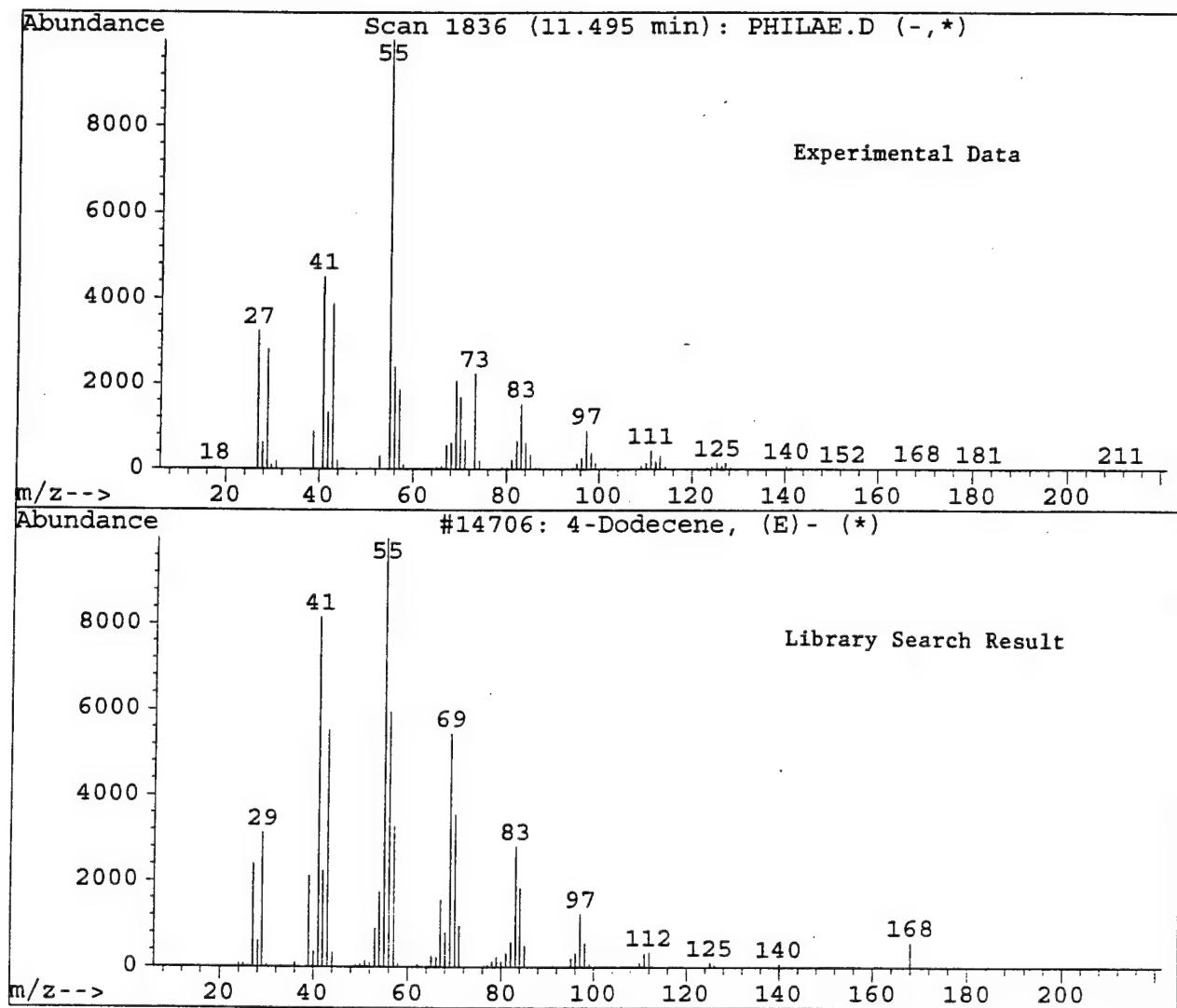


Figure 8. Results of library search of 11.5-min peak in GC-MS chromatogram shown in Figure 6.  
Library match obtained using NBS spectral database.

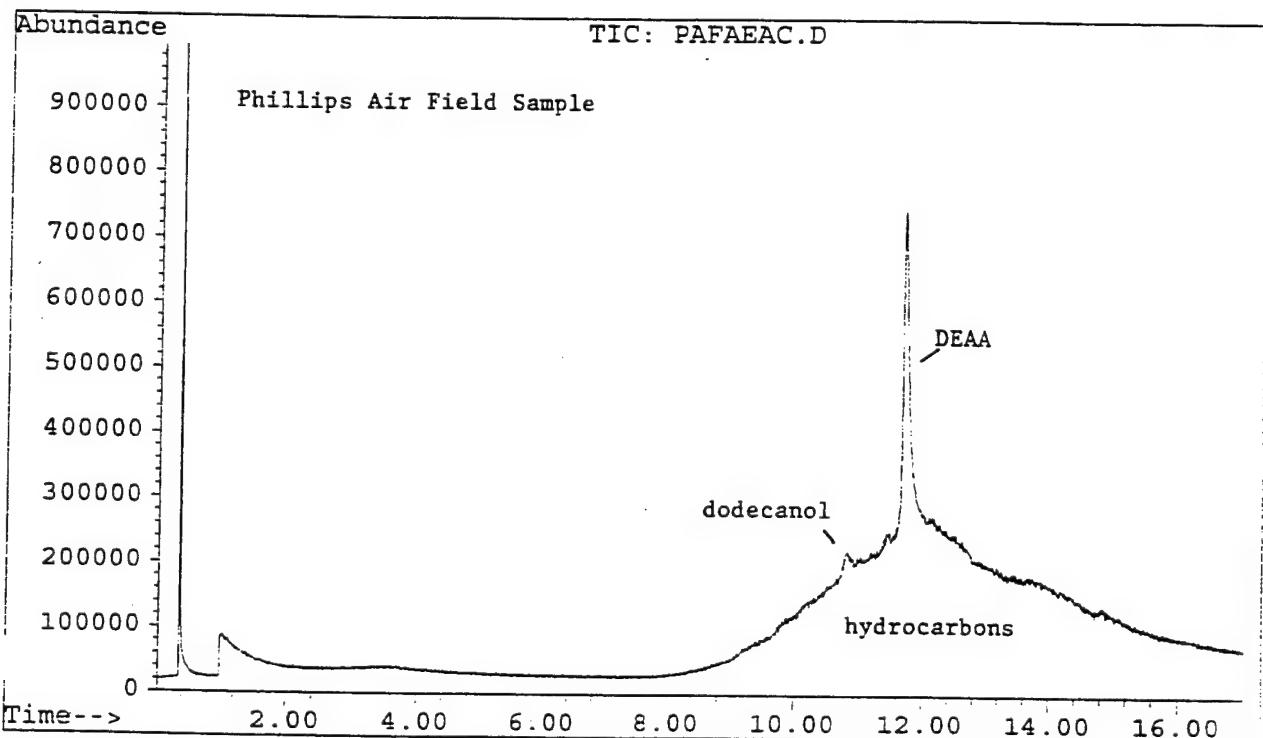
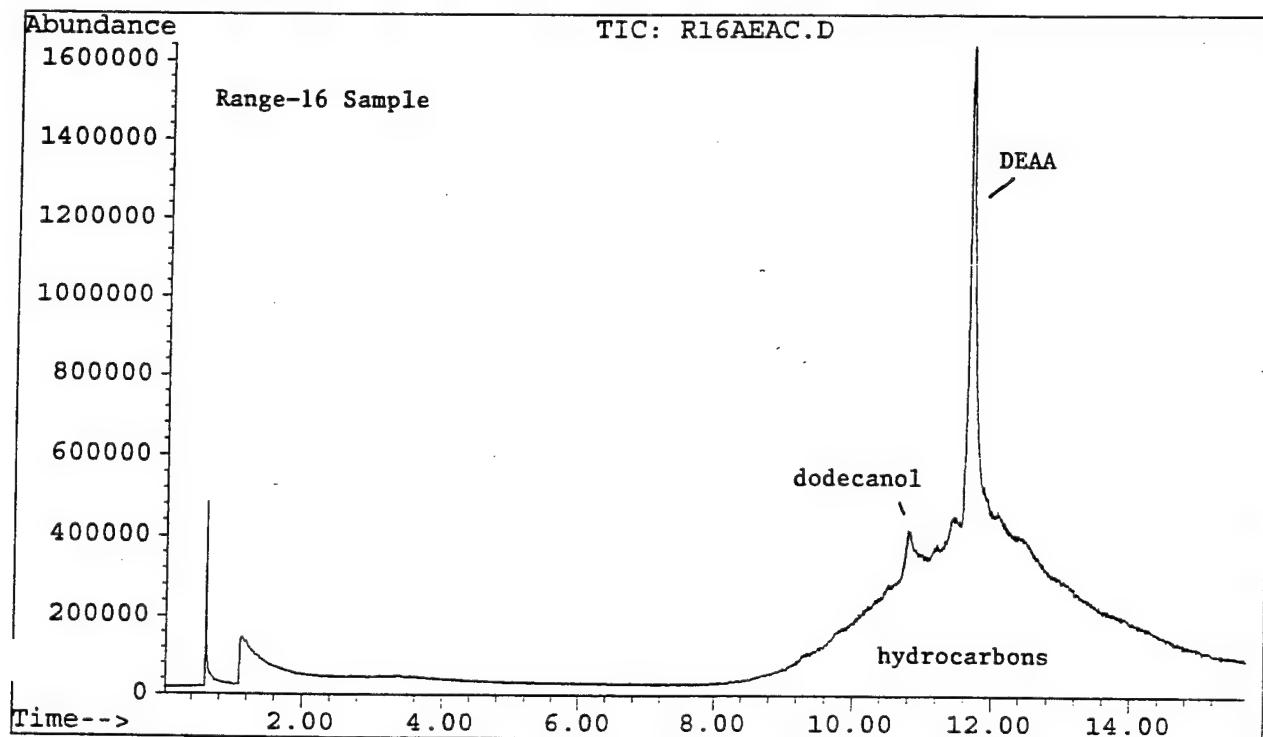


Figure 9. GC-MS results for acetone extract of R-16 and PAF sludge samples (250° C pulse). Samples allowed to dry for 1 day.

The chromatograms obtained from the 500° C pyrolysis of R-16 and PAF sludge "residues" (i.e., the samples remaining after acetone extraction) show a significantly decreased intensity for the peak eluting between 8 and 16 min (Figure 10). These results suggest that DEAA is the principal material responsible for the 8–16-min peak, and further suggest that the broadness of that peak results from the generation of many reaction products of DEAA (i.e., species eluting before DEAA are decomposition products, and species eluting after DEAA are condensation products [the latter would be formed by reaction of the acrylate group]). This has not yet been confirmed.

#### 4. DISCUSSION

4.1 Background/Literature Survey. A brief survey of the literature was performed since we had little previous knowledge regarding the chemical composition of sludge. The following information was obtained.

- (1) The four major types of odorants emitted by sewage and sewage treatment plants are hydrogen sulfide [ $\text{H}_2\text{S}$ ], isovaleric acid [3-methylbutanoic acid,  $(\text{CH}_3)_2\text{CHCH}_2\text{COOH}$ ], butanethiol [n-butylmercaptan,  $\text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{SH}$ ], and skatole [3-methyl-1H-indole, C9H9N] (Laing et al. 1994).
- (2) About 5–10% of fecal dry matter is made up of bacteria. The remainder is mostly the residues of digestive secretions that are not reabsorbed and probably include organic solid from bile, saliva, and gastric, pancreatic, and intestinal juices (Nasset 1968).
- (3) Fecal lipids include triglycerides, mono- and diglycerides, phospholipids, glycolipids, fatty acids and fatty acid salts (soaps), sterols, and cholesterol esters. Most of the lipids arise from intestinal bacterial cells and epithelial cells that have sloughed normally from the intestinal mucosa (Tietz 1976).
- (4) The stool content of neutral fat, free fatty acids, and soaps is relatively low. The total content of fat in feces should not exceed 60 g/L. Stool contains approximately 25% dry solids, and up to 25% of this dry matter may be total lipids (Tietz 1976).
- (5) See Table 3 for a list of the fatty acids found in the human body.

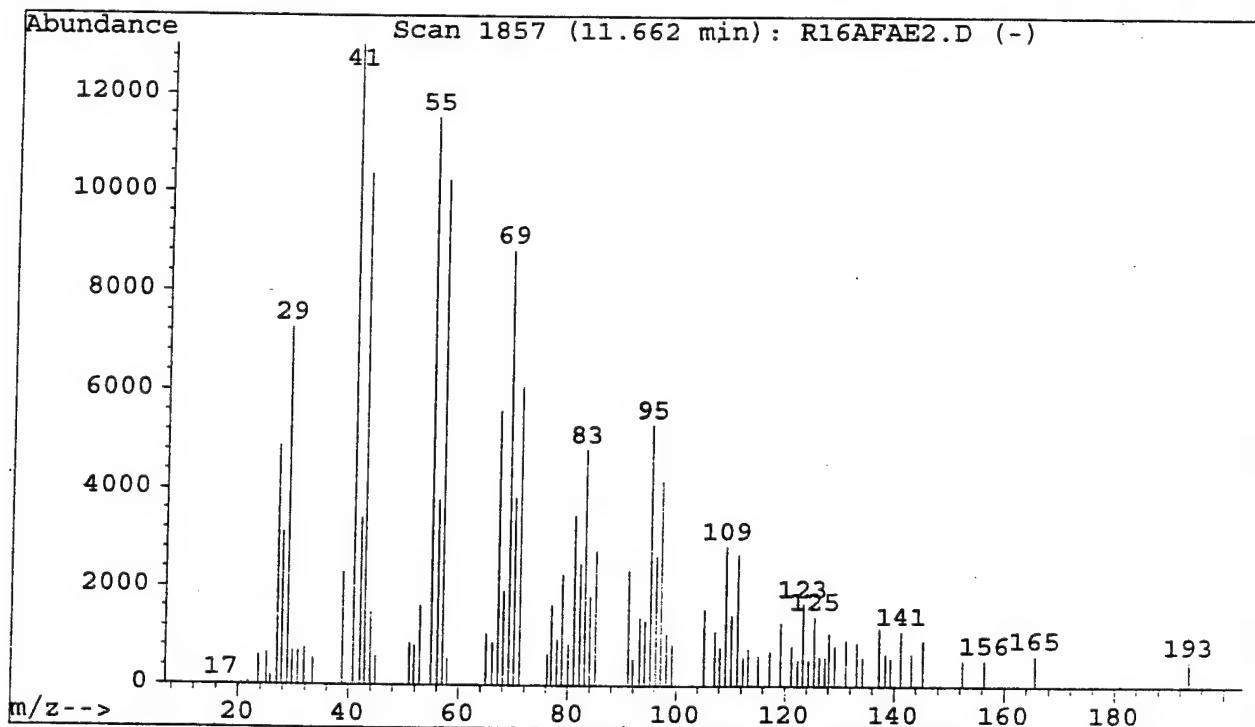
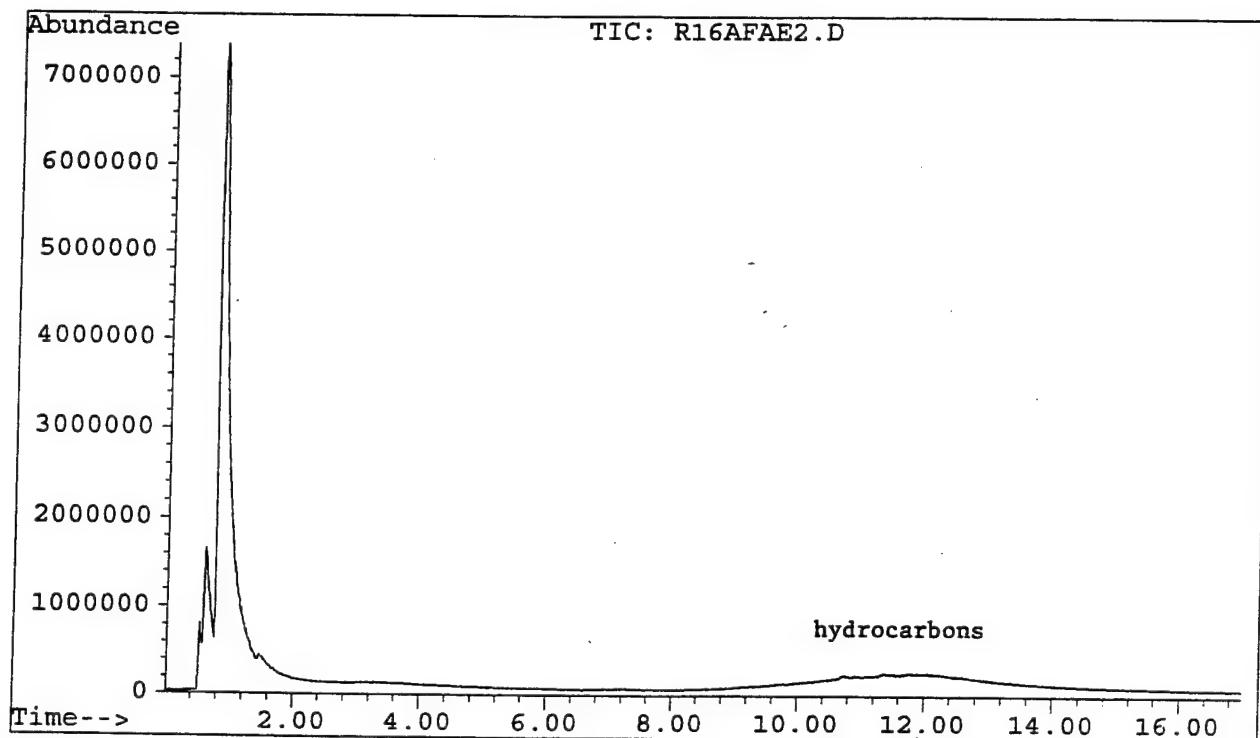


Figure 10. GC-MS results for R-16 sludge sample AFTER acetone extraction (500° C pulse). Compare with Figure 3 (shows reduction in intensity of 8–16-min peak).

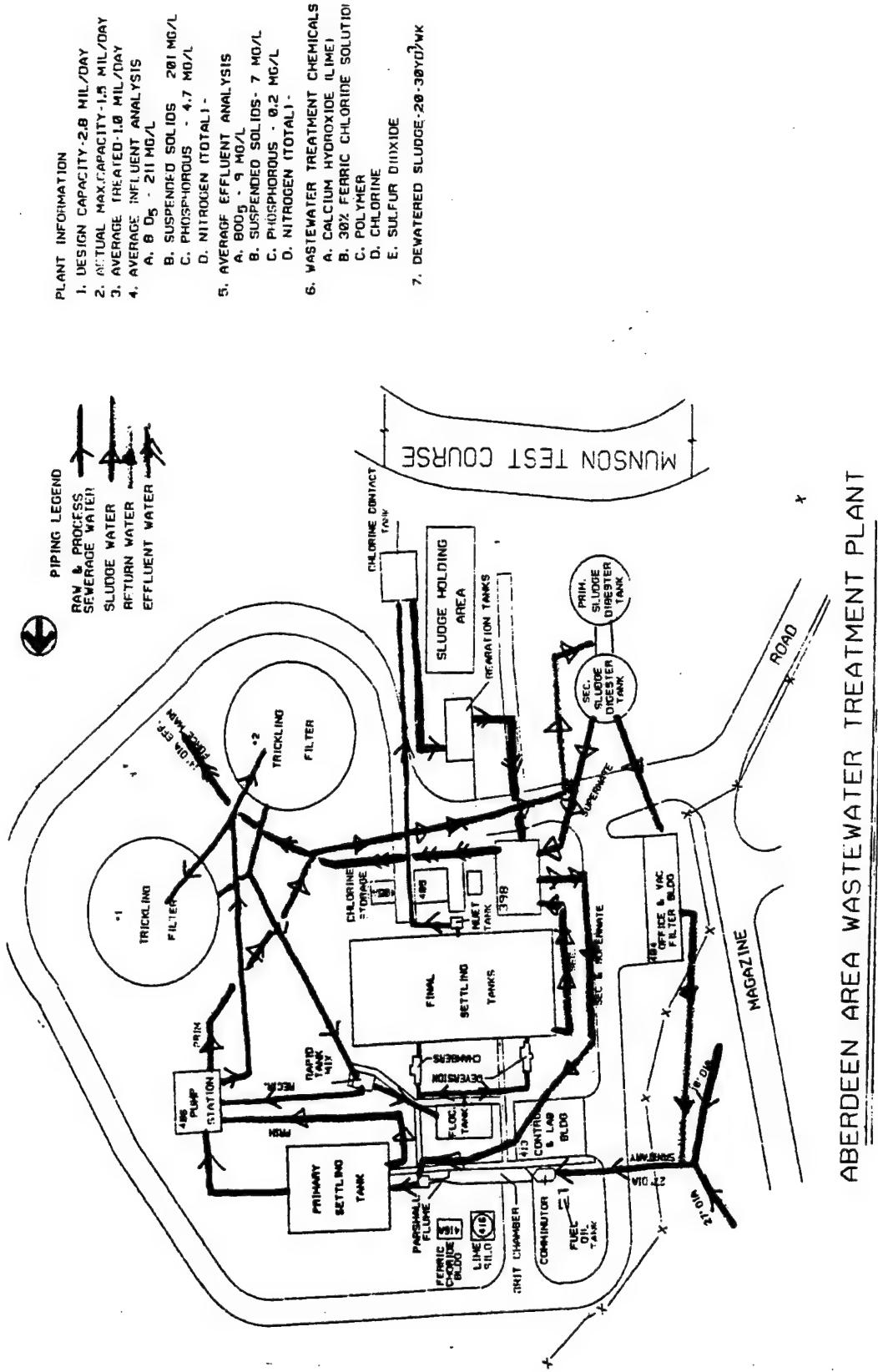


Figure 11. Aberdeen area wastewater treatment plant.

Table 3. Fatty Acids Commonly Found in the Human Body

Common Name	Systematic Name	No. of Carbons
Lauric	Dodecanoic	12
Myristic	Tetradecanoic	14
Palmitic	Hexadecanoic	16
Palmitoleic	9-Hexadecanoic	16
Stearic	Octadecanoic	18
Oleic	9-Octadecenoic	18
Linoleic	9,12-Octadecadienoic	18
Linolenic	9,12,15-Octadecatrienoic	18
$\gamma$ -Linolenic	6,9,12-Octadecatrienoic	18
Arachidonic	Eicosanoic	20
Behenic	Docosanoic	22
Lignoceric	Tetracosanoic	24

Reference: Tietz 1976.

(6) A "typical" process for sewage treatment involves (at least) the following steps:

- "clarify" an aqueous dispersion of sewage by letting materials settle to the bottom
- skim off oils and scum from the top of the dispersion
- collect the sediment
- process the sediment by either pressing it (squeezing moisture out) or directly drying it. (Note: it appears that pressing is the preferred method.)
- chemically test the sediment for metals content

- final-process material by either incineration or application to a field. (If composting, mix with soil and lime. Sludge is usually included at the 7-8% level when used as a fertilizer [Waller 1995]).

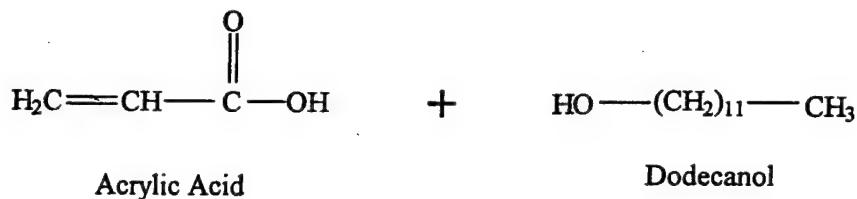
(7) At APG, a variety of physical, chemical, and biological methods are employed. The schematic diagram in Figure 11 illustrates the complete process through which the sewage is treated.

(8) In general, burning of treated sewage should not pose any "extraordinary" health risk. No fire warnings are issued to farmers on whose property sludge is applied. Two other warnings are issued: for a certain period of time, there should be no animals grazing and no vegetables growing on the applied area (Bio Grow Headquarters 1995).

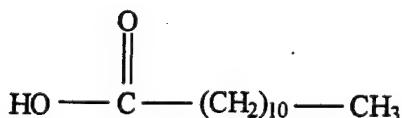
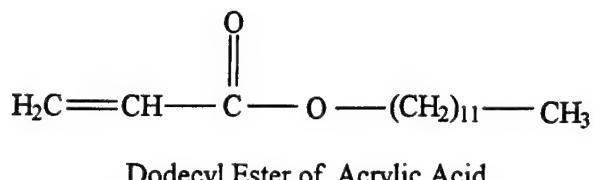
Based on this brief literature/background survey, the observation of DEAA in the R-16 and PAF sludge samples does not appear to be consistent with the expected composition of sludge. It is surprising that while DEAA appears to be closely related to fatty acids commonly found in the human body (and especially to lauric acid), it could not readily have been derived from any of the fatty acids. As illustrated in Figure 12, the "dodecyl ester" part of the DEAA would have to have come from dedecanol (an alcohol). To obtain an alcohol from a carboxylic acid such as lauric acid, a reduction reaction would have to have taken place. The "textbook" reaction for reduction of alcohol to carboxylic acids involves the use of lithium aluminum hydride and anhydrous ether. It is doubtful that this or an equivalent reaction could have occurred during the sewage treatment, unless, perhaps, appropriate enzymes were present in the sludge to result in an anaerobic conversion of the carboxylic acid to the alcohol.

If the DEAA were a biologically related compound present in the sludge, one would expect to observe a multitude of other biologically related compounds in the acetone extract as well. Since the DEAA alone appears to be relatively abundant in the samples, the possibility that it is naturally occurring is judged to be small. A more extensive survey of the literature would be necessary to confirm this.

**4.2 Mechanism for Generation of Pyrolysis Products in Table 2.** The products listed in Table 2, as well as many others, could be formed relatively easily by pyrolysis of DEAA. It is expected that small molecules, moderate-size molecules, and even polymers *will* form when DEAA is pyrolyzed. The mechanism for polymerization *will* be primarily through reaction of the double bond in the acrylate group,



(Condensation Reaction)  $\downarrow$  - H<sub>2</sub>O



Dodecanoic Acid (Lauric Acid)  
(cannot react to form Dodecyl Ester of Acrylic Acid)

**Figure 12. Chemical structure of dodecyl ester of acrylic acid, a component of sludge sampled from R-16 and PAF. The reaction illustrating possible synthetic route and the reason why the compound is probably not derived from a fatty acid are also shown.**

which is known to be fairly reactive (especially when heated or in the presence of radicals). Formation of polymers probably accounts for the smoke observed when acrylates, such as the 2-ethoxyethyl ester of acrylic acid (see section 4.3) and the DEAA extracted from R-16 sludge sample, are heated to decomposition. It is completely reasonable to assume that in the "soup" of hydrocarbon radicals resulting from pyrolysis of DEAA, many cyclic and noncyclic products will form.

4.3 Potential Health Hazard of the Dodecyl Ester of Acrylic Acid. Unfortunately, no information regarding the toxicity of the dodecyl ester of acrylic acid could be located. Information for acrylic acid and two acrylic acid esters is presented in the following paragraph (Sax and Lewis 1993). Of the three sets of information given, it is suspected that the last (i.e., the 2-ethylhexyl ester of acrylic acid) is the closest to the ester identified in the R-16 and PAF sludge samples. Material Safety Data Sheets for all three compounds are given in Appendix A.

*Acrylic Acid:*

CAS:	79-10-7
NIOSH:	AS 437500
DOT:	UN 2218
Molecular formula:	C <sub>3</sub> H <sub>4</sub> O <sub>2</sub>
Molecular weight:	72.07
Melting point:	13° C
Boiling point:	141° C
Density:	1.062
Vapor pressure:	10 mm @ 39.9° C
Flash point:	130° F (OC)
Vapor density:	2.45

Properties: Liquid, acrid odor. Misc in water, benzene, alcohol, chloroform, ether, and acetone.

Toxicity: Poison by ingestion, skin contact, and intraperitoneal routes. An experimental teratogen. A skin and eye irritant. Corrosive.

*Acrylic Acid, 2-Ethoxyethyl Ester:*

CAS:	106-74-1
NIOSH:	AS 9800000
Molecular formula:	C <sub>7</sub> H <sub>12</sub> O <sub>3</sub>
Molecular weight:	144.19

Toxicity: Moderately toxic by various routes. A skin and eye irritant. When heated to decomposition, it emits acrid smoke and fumes.

*Acrylic Acid, 2-Ethylhexyl Ester:*

CAS:	103-11-7
NIOSH:	AS 0855000
Molecular formula:	C <sub>11</sub> H <sub>20</sub> O <sub>2</sub>
Molecular weight:	184.31
Boiling point:	130° C @ 50 mm
Density:	0.8869 @ 20° C
Vapor pressure:	1 mm @ 50° C
Flash point:	180° F (OC)
Vapor density:	6.35

Properties: Liquid, acrid odor. Misc in water, benzene, alcohol, chloroform, ether, and acetone.

Toxicity: Moderately toxic by various routes. A skin and eye irritant. Moderate fire hazard. When heated to decomposition, it emits acrid smoke and fumes. To fight fire, use alcohol foam, CO<sub>2</sub>, dry chemical.

NOTE: Range personnel used water to try to extinguish the R-16 fire (Herron 1995).

**4.4 Relation of Results to Analysis/Modeling Reported by CHPPM.** In a briefing held by the ARL Risk Management Office, the Army Center for Health Promotion and Preventive Medicine (CHPPM) presented results of their analysis/modeling of the R-16 fire. The chemical analysis of the sludge, ash, and soil samples yielded concentrations for metals (silver, arsenic, cadmium, chromium, copper, iron, mercury, molybdenum, nickel, lead, selenium, and zinc), "BTEX" (benzene, toluene, ethylbenzene, m-, p-, and o-xylene), explosives (HMX, RDX, TNT, 2,6-DNT, 2,4-DNT), and semivolatiles (phenol, 4-methyl phenol, naphthalene, fluorene, N-nitrosodiphenylamine, phenylanthrene, pyrene, and bis(2-ethylhexyl) phthalate). In modeling the airborne toxins during the R-16 fire, CHPPM assumed maximum emissions from the sludge sample (i.e., during the fire, all of the toxins in the sludge volatilized and became airborne without concomitant decomposition).

There is no reason to try to directly compare results obtained by CHPPM and ICB since the analyses performed were so different in nature. CHPPM did not analyze for materials other than those mentioned previously because their analysis of the sludge was done to specifically verify that the material should not

have been regulated as hazardous waste. Results reported here by CCT/ICB for DEAA can therefore not be confirmed based on CHPPM data.

## 5. CONCLUSIONS

- (1) The pyrolysis products of soil (without sludge) from R-16 are consistent with those of cellulose-based materials.
- (2) The pyrolysis products of sludge taken from R-16 and PAF are very similar, suggesting that if there is no contamination of the PAF sludge, then the same should be true for the R-16 sludge.
- (3) The pyrolysis products of the R-16 sludge include cyclic hydrocarbons, such as benzene, toluene, phenol, and noncyclic hydrocarbons, such as acetaldehyde and "long chain" esters.
- (4) Acetone extraction of sludge samples from both R-16 and PAF yielded what appears to be DEAA. No other species of significant concentration were observed in acetone extracts which were allowed to completely dry. Samples that were allowed to dry for only 1 day were still "wet" (but contained neither water nor acetone) and showed smaller peaks in addition to a large DEAA peak.
- (5) A correlation between the presence of the DEAA and the expected content of the sludge samples was not established.
- (6) Toxicity information for DEAA was not located. Information for a related compound (i.e., the 2-ethylhexyl ester of acrylic acid) indicates that the material:
  - (a) is moderately toxic by various routes
  - (b) is a fire hazard
  - (c) emits acrid smoke when heated to decomposition.

## **6. RECOMMENDATIONS**

- (1) APG/ARL should confirm the presence of DEAA in sludge samples applied on R-16 and PAF.**
- (2) If the presence of DEAA is confirmed, APG/ARL should work with the owner/operators of the APG sewage treatment plant to:**
  - (a) identify its source.**
  - (b) determine its toxicity.**
- (3) Further application of sludge should be postponed until recommendations (1) and (2) are implemented.**

## 7. REFERENCES

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Griffiths, P. R., and J. A. de Haseth. Fourier Transform Infrared Spectroscopy, New York: John Wiley and Sons, pp. 604-607, 1986.

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Tietz, N. W. Fundamentals of Clinical Chemistry. Philadelphia, PA: W. B. Saunders Co., ch. 10, p. 524, 1976.

Waller, K. Private communication with Mr. Ken Waller, AMES-MESSCO Inc., Columbia, MD, 1995.

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**APPENDIX:**  
**MATERIAL SAFETY DATA SHEETS**

The Material Safety Data Sheets in this Appendix are used with permission of the copyright holder.

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Sigma Chemical Co.  
P.O. Box 14508  
St. Louis, MO 63178  
Phone: 314-771-5765

Aldrich Chemical Co., Inc.  
1001 West St. Paul  
Milwaukee, WI 53233  
Phone: 414-273-3850

Fluka Chemical Corp.  
980 South Second St.  
Ronkonkoma, NY 11779  
Phone: 516-467-0980  
Emergency Phone: 516-467-3535

SECTION 1. - - - - - CHEMICAL IDENTIFICATION- - - - -

PRODUCT #: 14723-0

NAME: ACRYLIC ACID, 99%

SECTION 2. - - - - - COMPOSITION/INFORMATION ON INGREDIENTS - - - - -

CAS #: 79-10-7

MF: C3H4O2

SYNONYMS

ACROLEIC ACID \* ACRYLIC ACID, GLACIAL \* ACRYLIC ACID, INHIBITED (DOT)  
\* ETHYLENECARBOXYLIC ACID \* GLACIAL ACRYLIC ACID \* KYSELINA AKRYLOVA  
(CZECH) \* PROPENE ACID \* PROPENOIC ACID \* 2-PROPENOIC ACID (9CI) \*  
RCRA WASTE NUMBER U008 \* UN2218 (DOT) \* VINYLFORMIC ACID \*

SECTION 3. - - - - - HAZARDS IDENTIFICATION - - - - -

LABEL PRECAUTIONARY STATEMENTS

COMBUSTIBLE (USA DEFINITION)

FLAMMABLE (EUROPEAN DEFINITION)

HIGHLY TOXIC (USA DEFINITION)

TOXIC (EUROPEAN DEFINITION)

TOXIC BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.

CAUSES BURNS.

READILY ABSORBED THROUGH SKIN.

IN CASE OF ACCIDENT OR IF YOU FEEL UNWELL, SEEK MEDICAL ADVICE  
IMMEDIATELY (SHOW THE LABEL WHERE POSSIBLE).

IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF  
WATER AND SEEK MEDICAL ADVICE.

TAKE OFF IMMEDIATELY ALL CONTAMINATED CLOTHING.

WEAR SUITABLE PROTECTIVE CLOTHING, GLOVES AND EYE/FACE  
PROTECTION.

STENCH.

SECTION 4. - - - - - FIRST-AID MEASURES- - - - -

IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH COPIOUS  
AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED  
CLOTHING AND SHOES.

ASSURE ADEQUATE FLUSHING OF THE EYES BY SEPARATING THE EYELIDS  
WITH FINGERS.

IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL  
RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.

IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS.

CALL A PHYSICIAN.

WASH CONTAMINATED CLOTHING BEFORE REUSE.

DISCARD CONTAMINATED SHOES.

SECTION 5. - - - - - FIRE FIGHTING MEASURES - - - - -

EXTINGUISHING MEDIA

CARBON DIOXIDE, DRY CHEMICAL POWDER OR APPROPRIATE FOAM.

SPECIAL FIREFIGHTING PROCEDURES

WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO  
PREVENT CONTACT WITH SKIN AND EYES.

COMBUSTIBLE LIQUID.

UNUSUAL FIRE AND EXPLOSIONS HAZARDS

EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

VAPOR MAY TRAVEL CONSIDERABLE DISTANCE TO SOURCE OF IGNITION AND  
FLASH BACK.

CONTAINER EXPLOSION MAY OCCUR UNDER FIRE CONDITIONS.

SECTION 6. - - - - - ACCIDENTAL RELEASE MEASURES- - - - -

EVACUATE AREA.

WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY  
RUBBER GLOVES.

ABSORB ON SAND OR VERMICULITE AND PLACE IN CLOSED CONTAINERS FOR  
DISPOSAL.

VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

SECTION 7. - - - - - HANDLING AND STORAGE- - - - -

REFER TO SECTION 8.

ADDITIONAL INFORMATION

WARNING: DO NOT USE STEAM OR ELECTRICAL HEATING SYSTEMS SUCH AS COILS,

JACKETS, TAPES, MANTLES, LIGHTS, ETC. TO THAW ANY SOLIDIFIED MONOMER. THE APPLICATION OF CONCENTRATED HEAT WILL CAUSE POLYMERIZATION AND POSSIBLE RUPTURE OF THE CONTAINER. DO NOT REFRIGERATE OR FREEZE. INHIBITED WITH 200 PPM HYDROQUINONE MONOMETHYL ETHER (MEHQ).

SECTION 8. - - - - - EXPOSURE CONTROLS/PERSONAL PROTECTION- - - - -

WEAR APPROPRIATE NIOSH/MSHA-APPROVED RESPIRATOR, CHEMICAL-RESISTANT GLOVES, SAFETY GOGGLES, OTHER PROTECTIVE CLOTHING.

SAFETY SHOWER AND EYE BATH.

USE ONLY IN A CHEMICAL FUME HOOD.

FACE SHIELD (8-INCH MINIMUM).

DO NOT BREATHE VAPOR.

DO NOT GET IN EYES, ON SKIN, ON CLOTHING.

AVOID PROLONGED OR REPEATED EXPOSURE.

WASH THOROUGHLY AFTER HANDLING.

HIGHLY TOXIC.

CORROSIVE.

KEEP TIGHTLY CLOSED.

STENCH.

KEEP AWAY FROM HEAT AND OPEN FLAME.

STORE IN A COOL DRY PLACE.

SECTION 9. - - - - - PHYSICAL AND CHEMICAL PROPERTIES - - - - -

APPEARANCE AND ODOR

COLORLESS LIQUID

BOILING POINT: 139 C

MELTING POINT: 13 C

FLASHPOINT 130 F

54C

AUTOIGNITION TEMPERATURE: 744 F 395C

UPPER EXPLOSION LEVEL: 13.7%

LOWER EXPLOSION LEVEL: 2%

VAPOR PRESSURE: 4MM 20 C 40MM 60 C

VAPOR DENSITY: 2.5

SPECIFIC GRAVITY: 1.051

SECTION 10. - - - - - STABILITY AND REACTIVITY - - - - -

INCOMPATIBILITIES

STRONG OXIDIZING AGENTS

STRONG BASES

MAY UNDERGO AUTOPOLYMERIZATION.

STORE AWAY FROM HEAT AND DIRECT SUNLIGHT.

HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS

TOXIC FUMES OF:

CARBON MONOXIDE, CARBON DIOXIDE

SECTION 11. - - - - - TOXICOLOGICAL INFORMATION - - - - -

ACUTE EFFECTS

MAY BE FATAL IF INHALED, SWALLOWED, OR ABSORBED THROUGH SKIN.

MATERIAL IS EXTREMELY DESTRUCTIVE TO TISSUE OF THE MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT, EYES AND SKIN.

INHALATION MAY BE FATAL AS A RESULT OF SPASM, INFLAMMATION AND EDEMA OF THE LARYNX AND BRONCHI, CHEMICAL PNEUMONITIS AND PULMONARY EDEMA.

SYMPTOMS OF EXPOSURE MAY INCLUDE BURNING SENSATION, COUGHING, WHEEZING, LARYNGITIS, SHORTNESS OF BREATH, HEADACHE, NAUSEA AND VOMITING.

RTECS NO: AS4375000

ACRYLIC ACID (ACGIH)

IRRITATION DATA

SKN-RBT 500 MG OPEN SEV

UCDS\*\* 2/2/65

SKN-RBT 5 MG/24H SEV

85JCAE -,309,86

EYE-RBT 1 MG SEV

UCDS\*\* 2/2/65

EYE-RBT 250 UG/24H SEV

85JCAE -,309,86

TOXICITY DATA

ORL-RAT LD50:33500 UG/KG

85GMAT -,16,82

IPR-RAT LD50:22 MG/KG

JDREAF 51,1632,72

UNR-RAT LD50:1250 MG/KG

GISAAA 49(10),64,84

ORL-MUS LD50:2400 MG/KG

BIJOAK 34,1196,40

IHL-MUS LC50:5300 MG/M3/2H

85GMAT -,16,82

IPR-MUS LD50:144 MG/KG

YKKZAJ 104,793,84

SCU-MUS LD50:1590 MG/KG

JPPMAB 21,85,69

UNR-MUS LD50:830 MG/KG

GISAAA 49(10),64,84

SKN-RBT LD50:280 UL/KG

TXAPPA 28,313,74

UNR-RBT LD50:250 MG/KG

GISAAA 49(10),64,84

TARGET ORGAN DATA

EFFECTS ON EMBRYO OR FETUS (FETOTOXICITY)  
SPECIFIC DEVELOPMENTAL ABNORMALITIES (MUSCULOSKELETAL SYSTEM)  
SPECIFIC DEVELOPMENTAL ABNORMALITIES (OTHER DEVELOPMENTAL ABNORMALITIES)  
ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES  
(RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR  
COMPLETE INFORMATION.

SECTION 12. - - - - - ECOLOGICAL INFORMATION - - - - -  
DATA NOT YET AVAILABLE.

SECTION 13. - - - - - DISPOSAL CONSIDERATIONS - - - - -  
THIS COMBUSTIBLE MATERIAL MAY BE BURNED IN A CHEMICAL INCINERATOR  
EQUIPPED WITH AN AFTERBURNER AND SCRUBBER.  
OBSERVE ALL FEDERAL, STATE AND LOCAL ENVIRONMENTAL REGULATIONS.

SECTION 14. - - - - - TRANSPORT INFORMATION - - - - -  
CONTACT ALDRICH CHEMICAL COMPANY FOR TRANSPORTATION INFORMATION.

SECTION 15. - - - - - REGULATORY INFORMATION - - - - -  
REVIEWS, STANDARDS, AND REGULATIONS

ACGIH TLV-TWA 2 PPM (SKIN)	85INA8 6,26,91
IARC CANCER REVIEW:ANIMAL NO ADEQUATE DATA	IMEMDT 19,47,79
IARC CANCER REVIEW:HUMAN NO ADEQUATE DATA	IMEMDT 19,47,79
IARC CANCER REVIEW:GROUP 3	IMSUDL 7,56,87
OEL-AUSTRALIA:TWA 10 PPM (30 MG/M3) JAN93	
OEL-BELGIUM:TWA 10 PPM (29 MG/M3) JAN93	
OEL-DENMARK:TWA 10 PPM (30 MG/M3) JAN93	
OEL-FRANCE:TWA 10 PPM (30 MG/M3) JAN93	
OEL-THE NETHERLANDS:TWA 10 PPM (30 MG/M3) JAN93	
OEL-RUSSIA:STEL 5 MG/M3 JAN93	
OEL-SWEDEN:TWA 10 PPM (30 MG/M3);STEL 15 PPM (45 MG/M3) JAN93	
OEL-SWITZERLAND:TWA 10 PPM (30 MG/M3) JAN93	
OEL-UNITED KINGDOM:TWA 10 PPM (30 MG/M3);STEL 20 PPM (60 MG/M3) JAN93	
OEL IN BULGARIA, COLOMBIA, JORDAN, KOREA CHECK ACGIH TLV	
OEL IN NEW ZEALAND, SINGAPORE, VIETNAM CHECK ACGIH TLV	
NIOSH REL TO ACRYLIC ACID-AIR:10H TWA 2 PPM (SK)	
NIOSH* DHHS #92-100,92	
NOHS 1974: HZD 03570; NIS 44; TNF 1679; NOS 41; TNE 28576	
NOES 1983: HZD 03570; NIS 58; TNF 3241; NOS 45; TNE 56513; TFE 15647	
EPA TSCA CHEMICAL INVENTORY, JUNE 1993	
EPA TSCA SECTION 8(E) STATUS REPORT 8EHQ-0386-0592	
ON EPA IRIS DATABASE	
EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, JULY 1994	
OSHA ANALYTICAL METHOD #28	
THIS PRODUCT IS SUBJECT TO SARA SECTION 313 REPORTING REQUIREMENTS.	
SECTION 16. - - - - - OTHER INFORMATION- - - - -	
THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. SIGMA, ALDRICH, FLUKA SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.	
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P.O. Box 14508  
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Phone: 314-771-5765

Aldrich Chemical Co., Inc.  
1001 West St. Paul  
Milwaukee, WI 53233  
Phone: 414-273-3850

Fluka Chemical Corp.  
980 South Second St.  
Ronkonkoma, NY 11779  
Phone: 516-467-0980  
Emergency Phone: 516-467-3535

SECTION 1. - - - - - CHEMICAL IDENTIFICATION- - - - -

PRODUCT #: A1915

NAME: (+-) ACRYLIC ACID 2-ETHYLHEXYL ESTER

SECTION 2. - - - - - COMPOSITION/INFORMATION ON INGREDIENTS - - - - -

CAS #: 103-11-7

MF: C11H20O2

SYNONYMS

2-ETHYLHEXYL ACRYLATE \* 2-ETHYLHEXYLESTER KYSELINY AKRYLOVE (CZECH) \*  
2-ETHYLHEXYL 2-PROPENOATE \* 1-HEXANOL, 2-ETHYL-, ACRYLATE \* OCTYL  
ACRYLATE \* 2-PROPENOIC ACID, 2-ETHYLHEXYL ESTER (9CI) \*

SECTION 3. - - - - - HAZARDS IDENTIFICATION - - - - -

LABEL PRECAUTIONARY STATEMENTS

TOXIC

MAY CAUSE CANCER.

IRRITATING TO EYES, RESPIRATORY SYSTEM AND SKIN.

MAY CAUSE SENSITIZATION BY SKIN CONTACT.

LACHRYMATOR.

COMBUSTIBLE.

IN CASE OF ACCIDENT OR IF YOU FEEL UNWELL, SEEK MEDICAL ADVICE  
IMMEDIATELY (SHOW THE LABEL WHERE POSSIBLE).

IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF  
WATER AND SEEK MEDICAL ADVICE.

WEAR SUITABLE PROTECTIVE CLOTHING, GLOVES AND EYE/FACE  
PROTECTION.

DO NOT BREATHE VAPOR.

SECTION 4. - - - - - FIRST-AID MEASURES- - - - -

IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH COPIOUS  
AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED  
CLOTHING AND SHOES.

ASSURE ADEQUATE FLUSHING OF THE EYES BY SEPARATING THE EYELIDS  
WITH FINGERS.

IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL  
RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.

IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS.  
CALL A PHYSICIAN.

WASH CONTAMINATED CLOTHING BEFORE REUSE.

DISCARD CONTAMINATED SHOES.

SECTION 5. - - - - - FIRE FIGHTING MEASURES - - - - -

EXTINGUISHING MEDIA

CARBON DIOXIDE, DRY CHEMICAL POWDER OR APPROPRIATE FOAM.

WATER SPRAY.

SPECIAL FIREFIGHTING PROCEDURES

WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO  
PREVENT CONTACT WITH SKIN AND EYES.

COMBUSTIBLE LIQUID.

UNUSUAL FIRE AND EXPLOSIONS HAZARDS

EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

SECTION 6. - - - - - ACCIDENTAL RELEASE MEASURES- - - - -

EVACUATE AREA.

WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY  
RUBBER GLOVES.

WEAR DISPOSABLE COVERALLS AND DISCARD THEM AFTER USE.

COVER WITH DRY LIME OR SODA ASH, PICK UP, KEEP IN A CLOSED CONTAINER  
AND HOLD FOR WASTE DISPOSAL.

VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

SECTION 7. - - - - - HANDLING AND STORAGE- - - - -

REFER TO SECTION 8.

ADDITIONAL INFORMATION

INHIBITED WITH 10 PPM HYDROQUINONE MONOMETHYL ETHER (MEHQ) OR 10 PPM  
HYDROQUINONE. DO NOT TRANSFER OR STORE UNDER AN INERT ATMOSPHERE  
BECAUSE AUTOPOLYMERIZATION MAY OCCUR. FIRE FIGHTING: THE USE OF WATER  
STREAMS FOR FIGHTING LARGE SCALE FIRES PRODUCES A FLOATING FIRE DUE  
TO THE MATERIAL'S INSOLUBILITY IN WATER.

SECTION 8. - - - - - EXPOSURE CONTROLS/PERSONAL PROTECTION- - - - -  
WEAR APPROPRIATE NIOSH/MSHA-APPROVED RESPIRATOR, CHEMICAL-RESISTANT  
GLOVES, SAFETY GOGGLES, OTHER PROTECTIVE CLOTHING.  
USE ONLY IN A CHEMICAL FUME HOOD.  
SAFETY SHOWER AND EYE BATH.  
DO NOT BREATHE VAPOR.  
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.  
WASH THOROUGHLY AFTER HANDLING.  
CARCINOGEN.  
IRRITANT.  
LACHRYMATOR.  
SENSITIZER.  
KEEP TIGHTLY CLOSED.  
KEEP AWAY FROM HEAT AND OPEN FLAME.  
HEAT- AND LIGHT-SENSITIVE.  
REFRIGERATE.

SECTION 9. - - - - - PHYSICAL AND CHEMICAL PROPERTIES - - - - -  
APPEARANCE AND ODOR

COLORLESS LIQUID  
BOILING POINT: 215 C TO 219 C  
FLASHPOINT 175 F  
79C  
UPPER EXPLOSION LEVEL: 6.4%  
LOWER EXPLOSION LEVEL: 0.8%  
VAPOR PRESSURE: 0.15MM 20 C  
VAPOR DENSITY: 6.4  
SPECIFIC GRAVITY: 0.885

SECTION 10. - - - - - STABILITY AND REACTIVITY - - - - -  
INCOMPATIBILITIES

STRONG OXIDIZING AGENTS  
MAY POLYMERIZE ON EXPOSURE TO LIGHT.  
HEAT-SENSITIVE.

STRONG ACIDS  
STRONG BASES

HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS

TOXIC FUMES OF:  
CARBON MONOXIDE, CARBON DIOXIDE

SECTION 11. - - - - - TOXICOLOGICAL INFORMATION - - - - -  
ACUTE EFFECTS

HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN.  
VAPOR OR MIST IS IRRITATING TO THE EYES, MUCOUS MEMBRANES AND UPPER  
RESPIRATORY TRACT.  
CAUSES SKIN IRRITATION.  
SYMPTOMS OF EXPOSURE MAY INCLUDE BURNING SENSATION, COUGHING,  
WHEEZING, LARYNGITIS, SHORTNESS OF BREATH, HEADACHE, NAUSEA AND  
VOMITING.  
MAY CAUSE ALLERGIC SKIN REACTION.

CHRONIC EFFECTS

CARCINOGEN.  
TO THE BEST OF OUR KNOWLEDGE, THE CHEMICAL, PHYSICAL, AND  
TOXICOLOGICAL PROPERTIES HAVE NOT BEEN THOROUGHLY INVESTIGATED.

RTECS NO: AT0855000

ACRYLIC ACID, 2-ETHYLHEXYL ESTER

IRRITATION DATA

SKN-RBT 20 MG/24H MOD	85JCAE -,372,86
SKN-RBT 500 MG OPEN MLD	UCDS** 11/3/71
SKN-RBT 10 MG/24H OPEN SEV	AMIHBC 4,119,51
EYE-RBT 5 MG SEV	AJOPAA 29,1363,46
EYE-RBT 500 MG/24H MLD	85JCAE -,372,86

TOXICITY DATA

ORL-RAT LD50:6500 UL/KG	UCDS** 11/3/71
IPR-RAT LD50:1670 MG/KG	AMPMAR 36,58,75
ORL-MUS LD50:4400 MG/KG	GTPZAB 26(9),52,82
IPR-MUS LD50:1326 MG/KG	JDREAF 51,526,72
SKN-RBT LD50:8480 UL/KG	AMIHBC 4,119,51

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES  
(RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR  
COMPLETE INFORMATION.

SECTION 12. - - - - - ECOLOGICAL INFORMATION - - - - -  
DATA NOT YET AVAILABLE.

SECTION 13. - - - - - DISPOSAL CONSIDERATIONS - - - - -

THIS COMBUSTIBLE MATERIAL MAY BE BURNED IN A CHEMICAL INCINERATOR EQUIPPED WITH AN AFTERBURNER AND SCRUBBER.

OBSERVE ALL FEDERAL, STATE AND LOCAL ENVIRONMENTAL REGULATIONS.

SECTION 14. - - - - - TRANSPORT INFORMATION - - - - -  
CONTACT SIGMA CHEMICAL COMPANY FOR TRANSPORTATION INFORMATION.

SECTION 15. - - - - - REGULATORY INFORMATION - - - - -  
REVIEWS, STANDARDS, AND REGULATIONS

IARC CANCER REVIEW:ANIMAL LIMITED EVIDENCE IMEMDT 60,475,94

IARC CANCER REVIEW:HUMAN INADEQUATE EVIDENCE IMEMDT 60,475,94

IARC CANCER REVIEW:GROUP 3 IMEMDT 60,475,94

OEL-RUSSIA:STEL 1 MG/M3 JAN93

OEL IN BULGARIA, COLOMBIA, JORDAN, KOREA CHECK ACGIH TLV

OEL IN NEW ZEALAND, SINGAPORE, VIETNAM CHECK ACGIH TLV

NOHS 1974: HZD 82082; NIS 17; TNF 1437; NOS 24; TNE 26428

NOES 1983: HZD 82082; NIS 9; TNF 519; NOS 12; TNE 10693; TFE 2341

EPA TSCA CHEMICAL INVENTORY, JUNE 1993

EPA TSCA 8(A) PRELIMINARY ASSESSMENT INFORMATION, FINAL RULE

FEREAC 47,26992,82

EPA TSCA SECTION 8(E) STATUS REPORT 8EHQ-1079-0262;8EHQ-1278-0262

EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, JULY 1994

SECTION 16. - - - - - OTHER INFORMATION- - - - -

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Fluka Chemical Corp.  
980 South Second St.  
Ronkonkoma, NY 11779  
Phone: 516-467-0980  
Emergency Phone: 516-467-3535

SECTION 1. - - - - - CHEMICAL IDENTIFICATION- - - - -

PRODUCT #: 01740  
NAME: 2-ETHOXYETHYL ACRYLATE

SECTION 2. - - - - - COMPOSITION/INFORMATION ON INGREDIENTS - - - - -

CAS #:106-74-1  
MF: C7H12O3

SYNONYMS

ACRYLIC ACID, 2-ETHOXYETHANOL ESTER \* CELLOSOLVE ACRYLATE \* ETHANOL,  
2-ETHOXY-, ACRYLATE \* ETHOXYETHYL ACRYLATE \* 2-ETHOXYETHYL ACRYLATE \*  
2-ETHOXYETHYLESTER KYSELINY AKRYLOVE (CZECH) \* 2-ETHOXYETHYL-2-  
PROPENOATE \* ETHYLENE GLYCOL MONOETHYL ETHER ACRYLATE \* ETHYLENE  
GLYCOL MONOETHYL ETHER PROPENOATE \* 2-PROPENOIC ACID, 2-ETHOXYETHYL  
ESTER \*

SECTION 3. - - - - - HAZARDS IDENTIFICATION - - - - -

LABEL PRECAUTIONARY STATEMENTS

HIGHLY TOXIC (USA DEFINITION)  
TOXIC (EUROPEAN DEFINITION)  
TOXIC BY INHALATION.

HARMFUL IN CONTACT WITH SKIN AND IF SWALLOWED.

CAUSES SEVERE IRRITATION.

IN CASE OF ACCIDENT OR IF YOU FEEL UNWELL, SEEK MEDICAL ADVICE  
IMMEDIATELY (SHOW THE LABEL WHERE POSSIBLE).

IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF  
WATER AND SEEK MEDICAL ADVICE.

WEAR SUITABLE PROTECTIVE CLOTHING, GLOVES AND EYE/FACE  
PROTECTION.

SECTION 4. - - - - - FIRST-AID MEASURES- - - - -

IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH COPIOUS  
AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED  
CLOTHING AND SHOES.

IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL  
RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.

IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS.  
CALL A PHYSICIAN IMMEDIATELY.

WASH CONTAMINATED CLOTHING BEFORE REUSE.

SECTION 5. - - - - - FIRE FIGHTING MEASURES - - - - -

EXTINGUISHING MEDIA

WATER SPRAY.

CARBON DIOXIDE, DRY CHEMICAL POWDER OR APPROPRIATE FOAM.

SPECIAL FIREFIGHTING PROCEDURES

WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO  
PREVENT CONTACT WITH SKIN AND EYES.

COMBUSTIBLE LIQUID.

UNUSUAL FIRE AND EXPLOSIONS HAZARDS

EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

SECTION 6. - - - - - ACCIDENTAL RELEASE MEASURES- - - - -

EVACUATE AREA.

WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY  
RUBBER GLOVES.

ABSORB ON SAND OR VERMICULITE AND PLACE IN CLOSED CONTAINERS FOR  
DISPOSAL.

VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

SECTION 7. - - - - - HANDLING AND STORAGE- - - - -

REFER TO SECTION 8.

SECTION 8. - - - - - EXPOSURE CONTROLS/PERSONAL PROTECTION- - - - -

WEAR APPROPRIATE NIOSH/MSHA-APPROVED RESPIRATOR, CHEMICAL-RESISTANT  
GLOVES, SAFETY GOGGLES, OTHER PROTECTIVE CLOTHING.

SAFETY SHOWER AND EYE BATH.

USE ONLY IN A CHEMICAL FUME HOOD.

DO NOT BREATHE VAPOR.

DO NOT GET IN EYES, ON SKIN, ON CLOTHING.

AVOID PROLONGED OR REPEATED EXPOSURE.

WASH THOROUGHLY AFTER HANDLING.

HIGHLY TOXIC.  
SEVERE IRRITANT.  
KEEP TIGHTLY CLOSED.  
KEEP AWAY FROM HEAT AND OPEN FLAME.  
STORE IN A COOL DRY PLACE.

SECTION 9. - - - - - PHYSICAL AND CHEMICAL PROPERTIES - - - - -

APPEARANCE AND ODOR

COLORLESS LIQUID  
BOILING POINT: 78 C/23MM.  
FLASHPOINT 150 F  
65C

SPECIFIC GRAVITY: 0.982

SECTION 10. - - - - - STABILITY AND REACTIVITY - - - - -

INCOMPATIBILITIES

STRONG OXIDIZING AGENTS

HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS

TOXIC FUMES OF:

CARBON MONOXIDE, CARBON DIOXIDE

SECTION 11. - - - - - TOXICOLOGICAL INFORMATION - - - - -

ACUTE EFFECTS

MAY BE FATAL IF INHALED.

HARMFUL IF SWALLOWED OR ABSORBED THROUGH SKIN.

CAUSES SEVERE IRRITATION.

HIGH CONCENTRATIONS ARE EXTREMELY DESTRUCTIVE TO TISSUES OF THE MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT, EYES AND SKIN.

SYMPTOMS OF EXPOSURE MAY INCLUDE BURNING SENSATION, COUGHING, WHEEZING, LARYNGITIS, SHORTNESS OF BREATH, HEADACHE, NAUSEA AND VOMITING.

TO THE BEST OF OUR KNOWLEDGE, THE CHEMICAL, PHYSICAL, AND TOXICOLOGICAL PROPERTIES HAVE NOT BEEN THOROUGHLY INVESTIGATED.

RTECS NO: AS9800000

ACRYLIC ACID, 2-ETHOXYETHYL ESTER

IRRITATION DATA

SKN-RBT 10 MG/24H OPEN MLD

AMIHBC 10,61,54

SKN-RBT 500 MG OPEN MLD

UCDS\*\* 6/6/69

EYE-RBT 20 MG OPEN SEV

AMIHBC 10,61,54

TOXICITY DATA

ORL-RAT LD50:1070 MG/KG

AMIHBC 10,61,54

SKN-RBT LD50:1010 UL/KG

AMIHBC 10,61,54

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION.

SECTION 12. - - - - - ECOLOGICAL INFORMATION - - - - -

DATA NOT YET AVAILABLE.

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## LIST OF ABBREVIATIONS

APG	Aberdeen Proving Ground
ARL	U.S. Army Research Laboratory
CCT	Chemical Characterization Team
CHPPM	Center for Health Promotion and Preventive Medicine
DEAA	dodecyl ester of acrylic acid
FTIR	Fourier Transform Infrared
GC	gas chromatography
HP	Hewlett Packard
ICB	Ignition and Combustion Branch
IR	infrared
IRD	infrared detector
MSD	mass spectroscopy detector
NBS	National Bureau of Standards
PAF	Phillips Air Field
PTFE	polytetrafluoroethylene
R-16	Range-16
UHP	ultrahigh purity

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# REPORT DOCUMENTATION PAGE

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	December 1996	Final, March–April 1995	
4. TITLE AND SUBTITLE		5. FUNDING NUMBERS	
Analysis of Pyrolysis Products of Sewage Sludge: Investigation of a Range Fire at Aberdeen Proving Ground (APG)		PR: IL161102AH43	
6. AUTHOR(S)			
Rose Pesce-Rodriguez			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)		8. PERFORMING ORGANIZATION REPORT NUMBER	
U.S. Army Research Laboratory ATTN: AMSRL-WM-PC Aberdeen Proving Ground, MD 21005-5066		ARL-MR-332	
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12a. DISTRIBUTION / AVAILABILITY STATEMENT		12b. DISTRIBUTION CODE	
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13. ABSTRACT (Maximum 200 words)			
<p>Soil, sludge, and ash samples taken from Range-16 (R-16) on Spesutie Island, Aberdeen Proving Ground (APG), were analyzed by pyrolysis-GC-FTIR-MS. The objective of the investigation was to identify toxic combustion/pyrolysis products that may have been responsible for physical discomfort and muscle spasms experienced by range personnel who attempted to extinguish a fire, which occurred on the range on 16 March 1995. It was found that the sludge samples generate small quantities of many cyclic and noncyclic hydrocarbons, including benzene, toluene, phenol, and acetaldehyde. The most interesting and potentially important finding of this investigation was that sludge samples from both R-16 and Phillips Air Field (PAF) contain the dodecyl ester of acrylic acid [<math>\text{CH}_2\text{CHCOO}(\text{CH}_2)_{11}\text{CH}_3</math>]. Toxicity data for a related ester suggests that the material is moderately toxic, a fire hazard, and emits acrid smoke when heated to decomposition. Based on a limited survey of the literature, it does not appear that esters of acrylic acid should be present in sludge.</p>			
14. SUBJECT TERMS		15. NUMBER OF PAGES 35	
sewage sludge, pyrolysis, combustion, acrylic acid, ester, sludge fire		16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL

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